

APPENDIX Y TO SUBPART B OF PART  
430—UNIFORM TEST METHOD FOR  
MEASURING THE ENERGY CONSUMPTION  
OF BATTERY CHARGERS

The provisions of this appendix are effective on the compliance date of any energy conservation standard for battery chargers.

### 1. SCOPE

This appendix covers the test requirements used to measure battery charger energy consumption for battery chargers operating at either DC or United States AC line voltage (115V at 60Hz).

### 2. DEFINITIONS

The following definitions are for the purposes of explaining the terminology associated with the test method for measuring battery charger energy consumption.<sup>1</sup>

2.1. *Active mode* or *charge mode* is the state in which the battery charger system is connected to the main electricity supply, and the battery charger is delivering current, equalizing the cells, and performing other one-time or limited-time functions in order to bring the battery to a fully charged state.

2.2. *Active power* or *real power* (P) means the average power consumed by a unit. For a two terminal device with current and voltage waveforms  $i(t)$  and  $v(t)$ , which are periodic with period T, the real or active power P is:

$$P = \frac{1}{T} \int_0^T v(t)i(t)dt$$

2.3. *Ambient temperature* is the temperature of the ambient air immediately surrounding the unit under test.

2.4. *Apparent power* (S) is the product of root-mean-square (RMS) voltage and RMS current in volt-amperes (VA).

2.5. *Batch charger* is a battery charger that charges two or more identical batteries simultaneously in a series, parallel, series-parallel, or parallel-series configuration. A batch charger does not have separate voltage or current regulation, nor does it have any separate indicators for each battery in the batch. When testing a batch charger, the term "battery" is understood to mean, collectively, all the batteries in the batch that are charged together. A charger can be both a batch charger and a multi-port charger or multi-voltage charger.

2.6. *Battery* or *battery pack* is an assembly of one or more rechargeable cells and any integral protective circuitry intended to provide electrical energy to a consumer product, and may be in one of the following

forms: (a) Detachable battery (a battery that is contained in a separate enclosure from the consumer product and is intended to be removed or disconnected from the consumer product for recharging); or (b) integral battery (a battery that is contained within the consumer product and is not removed from the consumer product for charging purposes). The word "intended" in this context refers to the whether a battery has been designed in such a way as to permit its removal or disconnection from its associated consumer product.

2.7. *Battery energy* is the energy, in watt-hours, delivered by the battery under the specified discharge conditions in the test procedure.

2.8. *Battery maintenance mode* or *maintenance mode* is the mode of operation when the battery charger is connected to the main electricity supply and the battery is fully charged, but is still connected to the charger.

2.9. *Battery rest period* is a period of time between discharge and charge or between charge and discharge, during which the battery is resting in an open-circuit state in ambient air.

2.10. *C-rate* is the rate of charge or discharge, calculated by dividing the charge or discharge current by the rated charge capacity of the battery.

2.11. *Cradle* is an electrical interface between an integral battery product and the rest of the battery charger designed to hold the product between uses.

2.12. *Equalization* is a process whereby a battery is overcharged, beyond what would be considered "normal" charge return, so that cells can be balanced, electrolyte mixed, and plate sulfation removed.

2.13. *Instructions* or *manufacturer's instructions* means the documentation packaged with a product in printed or electronic form and any information about the product listed on a Web site maintained by the manufacturer and accessible by the general public at the time of the test. It also includes any information on the packaging or on the product itself. "Instructions" also includes any service manuals or data sheets that the manufacturer offers to independent service technicians, whether printed or in electronic form.

2.14. *Measured charge capacity* of a battery is the product of the discharge current in amperes and the time in decimal hours required to reach the specified end-of-discharge voltage.

2.15. *Manual on-off switch* is a switch activated by the user to control power reaching the battery charger. This term does not apply to any mechanical, optical, or electronic switches that automatically disconnect mains power from the battery charger when a battery is removed from a cradle or charging base, or for products with non-

<sup>1</sup>For clarity on any other terminology used in the test method, please refer to IEEE Standard 1515-2000.

detachable batteries that control power to the product itself.

2.16. *Multi-port charger* means a battery charger that charges two or more batteries (which may be identical or different) simultaneously. The batteries are not connected in series or in parallel but with each port having separate voltage and/or current regulation. If the charger has status indicators, each port has its own indicator(s). A charger can be both a batch charger and a multi-port charger if it is capable of charging two or more batches of batteries simultaneously and each batch has separate regulation and/or indicator(s).

2.17. *Multi-voltage charger* is a battery charger that, by design, can charge a variety of batteries (or batches of batteries, if also a batch charger) that are of different rated battery voltages. A multi-voltage charger can also be a multi-port charger if it can charge two or more batteries simultaneously with independent voltage and/or current regulation.

2.18. *Off mode* is the condition, applicable only to units with manual on-off switches, in which the battery charger:

- (1) Is connected to the main electricity supply;
- (2) Is not connected to the battery; and
- (3) All manual on-off switches are turned off.

2.19. *Rated battery voltage* is specified by the manufacturer and typically printed on the label of the battery itself. If there are multiple batteries that are connected in series, the rated battery voltage of the batteries is the total voltage of the series configuration—that is, the rated voltage of each battery multiplied by the number of batteries connected in series. Connecting multiple batteries in parallel does not affect the rated battery voltage.

2.20. *Rated charge capacity* is the capacity claimed by a manufacturer, on a label or in instructions, the battery can store under specified test conditions, usually given in ampere-hours (Ah) or milliampere-hours (mAh) and typically printed on the label of the battery itself. If there are multiple batteries that are connected in parallel, the rated charge capacity of the batteries is the total charge capacity of the parallel configuration, that is, the rated charge capacity of each battery multiplied by the number of batteries connected in parallel. Connecting multiple batteries in series does not affect the rated charge capacity.

2.21. *Rated energy capacity* means the product (in watt-hours) of the rated battery voltage and the rated charge capacity.

2.22. *Standby mode or no-battery mode* means the condition in which:

- (1) The battery charger is connected to the main electricity supply;
- (2) The battery is not connected to the charger; and

(3) For battery chargers with manual on-off switches, all such switches are turned on.

2.23. *Total harmonic distortion* (THD), expressed as a percent, is the root mean square (RMS) value of an AC signal after the fundamental component is removed and interharmonic components are ignored, divided by the RMS value of the fundamental component.

2.24. *Unit under test* (UUT) in this appendix refers to the combination of the battery charger and battery being tested.

### 3. STANDARD TEST CONDITIONS

#### 3.1. General

The values that may be measured or calculated during the conduct of this test procedure have been summarized for easy reference in Table 3.1.

TABLE 3.1— LIST OF MEASURED OR CALCULATED VALUES

Name of measured or calculated value	Reference	Value
1. Duration of the charge and maintenance mode test .....	Section 5.2	
2. Battery Discharge Energy .....	Section 4.6	
3. Initial time and power (W) of the input current of connected battery	Section 5.8	
4. Active and Maintenance Mode Energy Consumption .....	Section 5.8	
5. Maintenance Mode Power .....	Section 5.9	
6. 24 Hour Energy Consumption ....	Section 5.10	
7. Standby Mode Power .....	Section 5.11	
8. Off Mode Power .....	Section 5.12	

#### 3.2. Verifying Accuracy and Precision of Measuring Equipment

a. Measurements of active power of 0.5 W or greater shall be made with an uncertainty of  $\leq 2$  percent at the 95 percent confidence level. Measurements of active power of less than 0.5 W shall be made with an uncertainty of  $\leq 0.01$  W at the 95 percent confidence level. The power measurement instrument shall, as applicable, have a resolution of:

- (1) 0.01 W or better for measurements up to 10 W;
- (2) 0.1 W or better for measurements of 10 to 100 W; or
- (3) 1 W or better for measurements over 100 W.

b. Measurements of energy (Wh) shall be made with an uncertainty of  $\leq 2$  percent at the 95 percent confidence level. Measurements of voltage and current shall be made with an uncertainty of  $\leq 1$  percent at the 95 percent confidence level. Measurements of temperature shall be made with an uncertainty of  $\leq 2$  °C at the 95 percent confidence level.

c. All equipment used to conduct the tests must be selected and calibrated to ensure that measurements will meet the above uncertainty requirements. For suggestions on

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measuring low power levels, see IEC 62301, (Reference for guidance only, see §430.4) especially Section 5.3.2 and Annexes B and D.

### 3.3. Setting Up the Test Room

All tests, battery conditioning, and battery rest periods shall be carried out in a room with an air speed immediately surrounding the UUT of  $\leq 0.5$  m/s. The ambient temperature shall be maintained at  $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  throughout the test. There shall be no intentional cooling of the UUT such as by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be conditioned, rested, and tested on a thermally non-conductive surface. When not undergoing active testing, batteries shall be stored at  $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ .

### 3.4. Verifying the UUT's Input Voltage and Input Frequency

a. If the UUT is intended for operation on AC line-voltage input in the United States, it shall be tested at 115 V at 60 Hz. If the UUT is intended for operation on AC line-voltage input but cannot be operated at 115 V at 60 Hz, it shall not be tested.

b. If a charger is powered by a low-voltage DC or AC input, and the manufacturer packages the charger with a wall adapter, sells, or recommends an optional wall adapter capable of providing that low voltage input, then the charger shall be tested using that wall adapter and the input reference source shall be 115 V at 60 Hz. If the wall adapter cannot be operated with AC input voltage at 115 V at 60 Hz, the charger shall not be tested.

c. If the UUT is designed for operation only on DC input voltage and the provisions of paragraph 3.4 (b) above do not apply, it shall be tested with one of the following input voltages: 5.0 V DC for products drawing power from a computer USB port or the midpoint of the rated input voltage range for all other products. The input voltage shall be within  $\pm 1$  percent of the above specified voltage.

d. If the input voltage is AC, the input frequency shall be within  $\pm 1$  percent of the specified frequency. The THD of the input voltage shall be  $\leq 2$  percent, up to and including the 13th harmonic. The crest factor of the input voltage shall be between 1.34 and 1.49.

e. If the input voltage is DC, the AC ripple voltage (RMS) shall be:

- (1)  $\leq 0.2$  V for DC voltages up to 10 V; or
- (2)  $\leq 2$  percent of the DC voltage for DC voltages over 10 V.

### UNIT UNDER TEST SETUP REQUIREMENTS

#### 4.1. General Setup

a. The battery charger system shall be prepared and set up in accordance with the manufacturer's instructions, except where

those instructions conflict with the requirements of this test procedure. If no instructions are given, then factory or "default" settings shall be used, or where there are no indications of such settings, the UUT shall be tested in the condition as it would be supplied to an end user.

b. If the battery charger has user controls to select from two or more charge rates (such as regular or fast charge) or different charge currents, the test shall be conducted at the fastest charge rate that is recommended by the manufacturer for everyday use, or, failing any explicit recommendation, the factory-default charge rate. If the charger has user controls for selecting special charge cycles that are recommended only for occasional use to preserve battery health, such as equalization charge, removing memory, or battery conditioning, these modes are not required to be tested. The settings of the controls shall be listed in the report for each test.

### 4.2. Selection and Treatment of the Battery Charger

The UUT, including the battery charger and its associated battery, shall be new products of the type and condition that would be sold to a customer. If the battery is lead-acid chemistry and the battery is to be stored for more than 24 hours between its initial acquisition and testing, the battery shall be charged before such storage.

### 4.3. Selection of Batteries To Use for Testing

a. For chargers with integral batteries, the battery packaged with the charger shall be used for testing. For chargers with detachable batteries, the battery or batteries to be used for testing will vary depending on whether there are any batteries packaged with the battery charger.

(1) If batteries are packaged with the charger, batteries for testing shall be selected from the batteries packaged with the battery charger, according to the procedure in section 4.3.b.

(2) If no batteries are packaged with the charger, but the instructions specify or recommend batteries for use with the charger, batteries for testing shall be selected from those recommended or specified in the instructions, according to the procedure in section 4.3.b.

(3) If no batteries are packaged with the charger and the instructions do not specify or recommend batteries for use with the charger, batteries for testing shall be selected from any that are suitable for use with the charger, according to the procedure in section 4.3.b.

b. From the detachable batteries specified above, the technician shall use Table 4.1 to select the batteries to be used for testing depending on the type of charger being tested.

Each row in the table represents a mutually exclusive charger type. The technician shall find the single applicable row for the UUT, and test according to those requirements.

c. A charger is considered as:

(1) Single-capacity if all associated batteries have the same rated charge capacity (see definition) and, if it is a batch charger,

all configurations of the batteries have the same rated charge capacity.

(2) Multi-capacity if there are associated batteries or configurations of batteries that have different rated charge capacities.

d. The selected battery or batteries will be referred to as the “test battery” and will be used through the remainder of this test procedure.

TABLE 4.1—BATTERY SELECTION FOR TESTING

Type of charger			Tests to perform	
Multi-voltage	Multi-port	Multi-capacity	Number of tests	Battery selection (from all configurations of all associated batteries)
No .....	No .....	No .....	1 .....	Any associated battery.
No .....	No .....	Yes .....	2 .....	Lowest charge capacity battery. Highest charge capacity battery.
No .....	Yes .....	Yes or No	2 .....	Use only one port and use the minimum number of batteries with the lowest rated charge capacity that the charger can charge. Use all ports and use the maximum number of identical batteries of the highest rated charge capacity the charger can accommodate.
Yes .....	No .....	No .....	2 .....	Lowest voltage battery. Highest voltage battery.
Yes .....	Yes to either or both		3 .....	Of the batteries with the lowest voltage, use the one with the lowest charge capacity. Use only one port. Of the batteries with the highest voltage, use the one with the lowest charge capacity. Use only one port. Use all ports and use the battery or the configuration of batteries with the highest total rated energy capacity.

#### 4.4. Limiting Other Non-Battery-Charger Functions

a. If the battery charger or product containing the battery charger does not have any additional functions unrelated to battery charging, this subsection may be skipped.

b. Any optional functions controlled by the user and not associated with the battery charging process (*e.g.*, the answering machine in a cordless telephone charging base) shall be switched off. If it is not possible to switch such functions off, they shall be set to their lowest power-consuming mode during the test.

c. If the battery charger takes any physically separate connectors or cables not required for battery charging but associated with its other functionality (such as phone lines, serial or USB connections, Ethernet, cable TV lines, *etc.*), these connectors or cables shall be left disconnected during the testing.

d. Any manual on-off switches specifically associated with the battery charging process shall be switched on for the duration of the charge, maintenance, and no-battery mode tests, and switched off for the off mode test.

#### 4.5. Accessing the Battery for the Test

a. The technician may need to disassemble the end-use product or battery charger to gain access to the battery terminals for the

Battery Discharge Energy Test in section 5.6. If the battery terminals are not clearly labeled, the technician shall use a voltmeter to identify the positive and negative terminals. These terminals will be the ones that give the largest voltage difference and are able to deliver significant current (0.2 C or 1/hr) into a load.

b. All conductors used for contacting the battery must be cleaned and burnished prior to connecting in order to decrease voltage drops and achieve consistent results.

c. Manufacturer's instructions for disassembly shall be followed, except those instructions that:

(1) Lead to any permanent alteration of the battery charger circuitry or function;

(2) Could alter the energy consumption of the battery charger compared to that experienced by a user during typical use, *e.g.*, due to changes in the airflow through the enclosure of the UUT; or

(3) Conflict requirements of this test procedure.

d. Care shall be taken by the technician during disassembly to follow appropriate safety precautions. If the functionality of the device or its safety features is compromised, the product shall be discarded after testing.

e. Some products may include protective circuitry between the battery cells and the remainder of the device. If the manufacturer

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provides a description for accessing the connections at the output of the protective circuitry, these connections shall be used to discharge the battery and measure the discharge energy. The energy consumed by the protective circuitry during discharge shall not be measured or credited as battery energy.

f. If the technician, despite diligent effort and use of the manufacturer's instructions, encounters any of the following conditions noted immediately below, the Battery Discharge Energy and the Charging and Maintenance Mode Energy shall be reported as "Not Applicable":

- (1) Inability to access the battery terminals;
- (2) Access to the battery terminals destroys charger functionality; or
- (3) Inability to draw current from the test battery.

### 4.6. Determining Charge Capacity for Batteries With No Rating

If there is no rating for the battery charge capacity on the battery or in the instructions, then the technician shall determine a discharge current that meets the following requirements. The battery shall be fully charged and then discharged at this constant-current rate until it reaches the end-of-discharge voltage specified in Table 5.2. The discharge time must be not less than 4.5 hours nor more than 5 hours. In addition, the

discharge test (Section 5.6) (which may not be starting with a fully-charged battery) shall reach the end-of-discharge voltage within 5 hours. The same discharge current shall be used for both the preparations step (Section 5.4) and the discharge test (Section 5.6). The test report shall include the discharge current used and the resulting discharge times for both a fully-charged battery and for the discharge test.

For this section, the battery is considered as "fully charged" when either (a) it has been charged by the UUT until an indicator on the UUT shows that the charge is complete, or (b) it has been charged by a battery analyzer at a current not greater than the discharge current until the battery analyzer indicates that the battery is fully charged.

When there is no capacity rating, a suitable discharge current must generally be determined by trial and error. Since the conditioning step does not require constant-current discharges, the trials themselves may also be counted as part of battery conditioning.

### 5. TEST MEASUREMENT

The test sequence to measure the battery charger energy consumption is summarized in Table 5.1, and explained in detail below. Measurements shall be made under test conditions and with the equipment specified in Sections 3 and 4.

TABLE 5.1—TEST SEQUENCE

Step	Description	Data taken?	Equipment needed				
			Test battery	Charger	Battery analyzer or constant-current load	AC power meter	Thermometer (for flooded lead-acid battery chargers only)
1 ....	Record general data on UUT; Section 5.1 .....	Yes ....	X	X	.....	.....	.....
2 ....	Determine test duration; Section 5.2 .....	No ....	.....	.....	.....	.....	.....
3 ....	Battery conditioning; Section 5.3 .....	No ....	X	X	X	.....	.....
4 ....	Prepare battery for charge test; Section 5.4 .....	No ....	X	X	.....	.....	.....
5 ....	Battery rest period; Section 5.5 .....	No ....	X	.....	.....	.....	X
6 ....	Conduct Charge Mode and Battery Maintenance Mode Test; Section 5.6.	Yes ....	X	X	.....	X	.....
7 ....	Battery Rest Period; Section 5.7 .....	No ....	X	.....	.....	.....	X
8 ....	Battery Discharge Energy Test; Section 5.8 .....	Yes ....	X	.....	X	.....	.....
9 ....	Determining the Maintenance Mode Power; Section 5.9.	Yes ....	X	X	.....	X	.....
10 ..	Calculating the 24-Hour Energy Consumption; Section 5.10.	No ....	.....	.....	.....	.....	.....
11 ..	Standby Mode Test; Section 5.11 .....	Yes ....	.....	X	.....	X	.....
12 ..	Off Mode Test; Section 5.12 .....	Yes ....	.....	X	.....	X	.....

### 5.1. Recording General Data on the UUT

The technician shall record:

- (1) The manufacturer and model of the battery charger;
- (2) The presence and status of any additional functions unrelated to battery charging;

- (3) The manufacturer, model, and number of batteries in the test battery;

- (4) The rated battery voltage of the test battery;

- (5) The rated charge capacity of the test battery; and

- (6) The rated charge energy of the test battery.

(7) The settings of the controls, if battery charger has user controls to select from two or more charge rates

*5.2. Determining the Duration of the Charge and Maintenance Mode Test*

a. The charging and maintenance mode test, described in detail in section 5.8, shall be 24 hours in length or longer, as determined by the items below. Proceed in order until a test duration is determined.

(1) If the battery charger has an indicator to show that the battery is fully charged, that indicator shall be used as follows: If the indicator shows that the battery is charged after 19 hours of charging, the test shall be terminated at 24 hours. Conversely, if the

full-charge indication is not yet present after 19 hours of charging, the test shall continue until 5 hours after the indication is present.

(2) If there is no indicator, but the manufacturer's instructions indicate that charging this battery or this capacity of battery should be complete within 19 hours, the test shall be for 24 hours. If the instructions indicate that charging may take longer than 19 hours, the test shall be run for the longest estimated charge time plus 5 hours.

(3) If there is no indicator and no time estimate in the instructions, but the charging current is stated on the charger or in the instructions, calculate the test duration as the longer of 24 hours or:

$$\text{Duration} = 1.4 \cdot \frac{\text{Rated Charge Capacity (Ah)}}{\text{Charge Current (A)}} + 5\text{h}$$

b. If none of the above applies, the duration of the test shall be 24 hours.

*5.3. Battery Conditioning*

a. No conditioning is to be done on lead-acid or lithium-ion batteries. The test technician shall proceed directly to battery preparation, section 5.4, when testing chargers for these batteries.

b. Products with integral batteries will have to be disassembled per the instructions in section 4.5, and the battery disconnected from the charger for discharging.

c. Batteries of other chemistries that have not been previously cycled are to be conditioned by performing two charges and two discharges, followed by a charge, as below. No data need be recorded during battery conditioning.

(1) The test battery shall be fully charged for the duration specified in section 5.2 or longer using the UUT.

(2) The test battery shall then be fully discharged using either:

(i) A battery analyzer at a rate not to exceed 1 C, until its average cell voltage under load reaches the end-of-discharge voltage specified in Table 5.2 for the relevant battery chemistry; or

(ii) The UUT, until the UUT ceases operation due to low battery voltage.

(3) The test battery shall again be fully charged as in step c.(1) of this section.

(4) The test battery shall again be fully discharged as per step c.(2) of this section.

(5) The test battery shall be again fully charged as in step c.(1) of this section.

d. Batteries of chemistries other than lead-acid or lithium-ion that are known to have been through at least two previous full

charge/discharge cycles shall only be charged once per step c.(5), of this section.

*5.4. Preparing the Battery for Charge Testing*

Following any conditioning prior to beginning the battery charge test (section 5.6), the test battery shall be fully discharged for the duration specified in section 5.2 or longer using a battery analyzer.

*5.5. Resting the Battery*

The test battery shall be rested between preparation and the battery charge test. The rest period shall be at least one hour and not exceed 24 hours. For batteries with flooded cells, the electrolyte temperature shall be less than 30 °C before charging, even if the rest period must be extended longer than 24 hours.

*5.6. Testing Charge Mode and Battery Maintenance Mode*

a. The Charge and Battery Maintenance Mode test measures the energy consumed during charge mode and some time spent in the maintenance mode of the UUT. Functions required for battery conditioning that happen only with some user-selected switch or other control shall not be included in this measurement. (The technician shall manually turn off any battery conditioning cycle or setting.) Regularly occurring battery conditioning or maintenance functions that are not controlled by the user will, by default, be incorporated into this measurement.

b. During the measurement period, input power values to the UUT shall be recorded at least once every minute.

(1) If possible, the technician shall set the data logging system to record the average

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power during the sample interval. The total energy is computed as the sum of power samples (in watts) multiplied by the sample interval (in hours).

(2) If this setting is not possible, then the power analyzer shall be set to integrate or accumulate the input power over the measurement period and this result shall be used as the total energy.

c. The technician shall follow these steps:

(1) Ensure that the user-controllable device functionality not associated with battery charging and any battery conditioning cycle or setting are turned off, as instructed in section 4.4;

(2) Ensure that the test battery used in this test has been conditioned, prepared, discharged, and rested as described in sections 5.3 through 5.7;

(3) Connect the data logging equipment to the battery charger;

(4) Record the start time of the measurement period, and begin logging the input power;

(5) Connect the test battery to the battery charger within 3 minutes of beginning logging. For integral battery products, connect the product to a cradle or wall adapter within 3 minutes of beginning logging;

(6) After the test battery is connected, record the initial time and power (W) of the input current to the UUT. These measurements shall be taken within the first 10 minutes of active charging;

(7) Record the input power for the duration of the "Charging and Maintenance Mode Test" period, as determined by section 5.2. The actual time that power is connected to the UUT shall be within  $\pm 5$  minutes of the specified period; and

(8) Disconnect power to the UUT, terminate data logging, and record the final time.

### 5.7. Resting the Battery

The test battery shall be rested between charging and discharging. The rest period shall be at least 1 hour and not more than 4 hours, with an exception for flooded cells. For batteries with flooded cells, the electrolyte temperature shall be less than 30 °C before charging, even if the rest period must be extended beyond 4 hours.

### 5.8. Battery Discharge Energy Test

a. If multiple batteries were charged simultaneously, the discharge energy is the sum of the discharge energies of all the batteries.

(1) For a multi-port charger, batteries that were charged in separate ports shall be discharged independently.

(2) For a batch charger, batteries that were charged as a group may be discharged individually, as a group, or in sub-groups connected in series and/or parallel. The position

of each battery with respect to the other batteries need not be maintained.

b. During discharge, the battery voltage and discharge current shall be sampled and recorded at least once per minute. The values recorded may be average or instantaneous values.

c. For this test, the technician shall follow these steps:

(1) Ensure that the test battery has been charged by the UUT and rested according to the procedures above.

(2) Set the battery analyzer for a constant discharge current of 0.2 °C and the end-of-discharge voltage in Table 5.2 for the relevant battery chemistry.

(3) Connect the test battery to the analyzer and begin recording the voltage, current, and wattage, if available from the battery analyzer. When the end-of-discharge voltage is reached or the UUT circuitry terminates the discharge, the test battery shall be returned to an open-circuit condition. If current continues to be drawn from the test battery after the end-of-discharge condition is first reached, this additional energy is not to be counted in the battery discharge energy.

d. If not available from the battery analyzer, the battery discharge energy (in watt-hours) is calculated by multiplying the voltage (in volts), current (in amperes), and sample period (in hours) for each sample, and then summing over all sample periods until the end-of-discharge voltage is reached.

### 5.9. Determining the Maintenance Mode Power

After the measurement period is complete, the technician shall determine the average maintenance mode power consumption by examining the power-versus-time data from the charge and maintenance test and:

(1) If the maintenance mode power is cyclic or shows periodic pulses, compute the average power over a time period that spans a whole number of cycles and includes at least the last 4 hours.

(2) Otherwise, calculate the average power value over the last 4 hours.

### 5.10. Determining the 24-Hour Energy Consumption

The accumulated energy or the average input power, integrated over the test period from the charge and maintenance mode test, shall be used to calculate 24-hour energy consumption.

TABLE 5.2—REQUIRED BATTERY DISCHARGE RATES AND END-OF-DISCHARGE BATTERY VOLTAGES

Battery chemistry	Discharge rate C	End-of-discharge voltage volts per cell
Valve-Regulated Lead Acid (VRLA) .....	0.2	1.75
Flooded Lead Acid .....	0.2	1.70
Nickel Cadmium (NiCd) .....	0.2	1.0
Nickel Metal Hydride (NiMH) .....	0.2	1.0
Lithium Ion (Li-Ion) .....	0.2	2.5
Lithium Polymer .....	0.2	2.5
Rechargeable Alkaline .....	0.2	0.9
Nanophosphate Lithium Ion .....	0.2	2.0
Silver Zinc .....	0.2	1.2

#### 5.11. Standby Mode Energy Consumption Measurement

The standby mode measurement depends on the configuration of the battery charger, as follows.

a. Conduct a measurement of standby power consumption while the battery charger is connected to the power source. Disconnect the battery from the charger, allow the charger to operate for at least 30 minutes, and record the power (*i.e.*, watts) consumed as the time series integral of the power consumed over a 10-minute test period, divided by the period of measurement. If the battery charger has manual on-off switches, all must be turned on for the duration of the standby mode test.

b. Standby mode may also apply to products with integral batteries. If the product uses a cradle and/or adapter for power conversion and charging, then “disconnecting the battery from the charger” will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and standby mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and standby mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and standby mode measurement is not applicable.

#### 5.12. Off Mode Energy Consumption Measurement

The off mode measurement depends on the configuration of the battery charger, as follows.

a. If the battery charger has manual on-off switches, record a measurement of off mode energy consumption while the battery charger is connected to the power source. Remove the battery from the charger, allow the charger to operate for at least 30 minutes, and record the power (*i.e.*, watts) consumed as the time series integral of the power consumed over a 10-minute test period, divided by the period of measurement, with all manual on-off switches turned off. If the battery charger does not have manual on-off switches, record that the off mode measurement is not applicable to this product.

b. Off mode may also apply to products with integral batteries. If the product uses a cradle and/or adapter for power conversion and charging, then “disconnecting the battery from the charger” will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and off mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and off mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and off mode measurement is not applicable.

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### APPENDIX Z TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF EXTERNAL POWER SUPPLIES

1. *Scope*: This appendix covers the test requirements used to measure energy consumption of external power supplies.

2. *Definitions*: The following definitions are for the purposes of understanding terminology associated with the test method for measuring external power supply energy consumption. For clarity on any other terminology used in the test method, please refer to IEC Standard 60050 or IEEE Standard 100. (Reference for guidance only, see § 430.4.)

a. *Active mode* means the mode of operation when the external power supply is connected to the main electricity supply and the output is (or “all outputs are” for a multiple-voltage external power supply) connected to a load (or “loads” for a multiple-voltage external power supply).